Unlocking teeth

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8.5 Conclusion / Summary

This research was conducted as part of the international research project NEXUS1492 which studied the impacts of the colonial encounters in the Caribbean. As part of the second project that focused on the development and application of biogeochemical methods to address human mobility, this work combined the exploration of a new isotopic technique (Nd isotope analysis) and evaluated already established methods (Sr, O, C isotope analysis).

This work successfully applied Nd isotope analysis to human dental enamel. This required a modified chemical chromatographic separation procedure that allowed the processing of large samples while keeping the blank as low as possible due to small Nd concentrations in dental enamel (0.1 – 21.0 ppb). This work indicated that Nd isotope can provide additional information on mobility, potentially addressing the limitations associated with other isotopic provenancing techniques (Sr, Pb, O, H). Successful analyses required >100 pg of Nd which limits the applicability of the technique as this amount of Nd is not always present in dental elements. Furthermore, while the majority of human enamel is indistinguishable from the geological location in which the enamel was formed, Nd isotope composition in dental enamel did not always correspond to expectations based on the geological locations. Further research is needed to understand Nd cycling in the environment and human tissues, and the variation of Nd in dental tissues needs to be evaluated by analysing dental elements from various geological contexts. Technical developments resulting in improved sensitive of measurements may make this technique more applicable to forensic and archaeological studies and open up new opportunities to study the past. The addition of Nd to the human provenancing repertoire would be of particular use in the Caribbean, where mobility patterns in individuals from coastal areas could be more reliably assessed. This is due to the differential characteristics of the Nd isotope system compared to other isotope systems as strontium and oxygen. Compared to strontium, the Nd isotope composition in coastal environments is not affected by sea spray and thus reflecting the isotopic variation of the local geology rather than the sea. Unlike oxygen isotopes, which have similar values in coastal regions, Nd isotopes are more likely to discern differences between various coastal environments. This improved spatial resolution could thus contribute to better understanding of past human mobility patterns in the Caribbean.

To increase the robustness of archaeological and forensic interpretations based on isotopic analyses, it is crucial that isotopic variability within a single dental element (intradental), between multiple dental elements of the same individual (interdental) and populational

isotopic variability is quantified. This work established that a single sample location is not representative for the total dental enamel Sr, O and C isotope variation. Enamel samples should be taken from the inner enamel, with no preference for a particular region as lateral and cuspal enamel are expected to provide comparable results. This research indicated that carious enamel should be avoided for sampling as this produced inconsistent isotopic data. This work highlighted that for modern Dutch individuals Sr isotope variation > 0.0002 is required to argue for mobility and differences under 2 ‰ are negligible for $\delta^{18}O$ and $\delta^{13}C$. To quantify the isotopic (intraindividual) variability in other modern and archaeological populations from geologically more complex regions than the Netherlands, studies will need to analyse multiple samples of the same dental element. More work is needed on dental elements other than third molars, and on the isotopic composition of enamel affected by caries. This will result in more robust interpretations of diet and mobility in archaeological and forensic studies. For the Caribbean, improving the robustness of isotopic techniques provides a more detailed characterisation of mobility and dietary patterns in Amerindian populations allowing for enhanced reconstructions of the impact of the interactions with European and African populations after 1492.

Reference materials, also known as isotopic baselines or isoscapes, are needed to interpret the results from isotopic analyses of human tissues. It is essential that these reference materials, such as the local geology, tap water, and dietary resources, are correlated to human tissue values. For modern globalised societies the preferred reference materials are human tissues, as the isotopic values of modern human tissues may become incompatible with from those of the local environment and geology due to increasing globalisation. In the Caribbean the archaeological isotopic variation across the islands has been well established. To be able to apply isotopic techniques in forensic cases in the Caribbean area, however, modern baselines or isoscapes should first be established.

Isotope research should always be performed complementary to other analyses and not be taken lightly as the destruction of the tooth enamel can impair other analyses (wear, aging, DNA, metrics, etc.) or future techniques that are still being developed. Furthermore, the teeth derived from an individual come from a specific archaeological or forensic context, and isotopic results should be interpreted within that local framework. This becomes particularly important in the data driven age, where multiple datasets are combined in order to address new research questions. Improving the standardisation and transparency of analytical procedures in isotopic research will result in more interoperability and optimisation of techniques between labs. Combining isotopic data from different labs and complementing this with the information

from other techniques and analyses will allow the field to address research questions on a new scale, further unlocking the potential information that human teeth contain.